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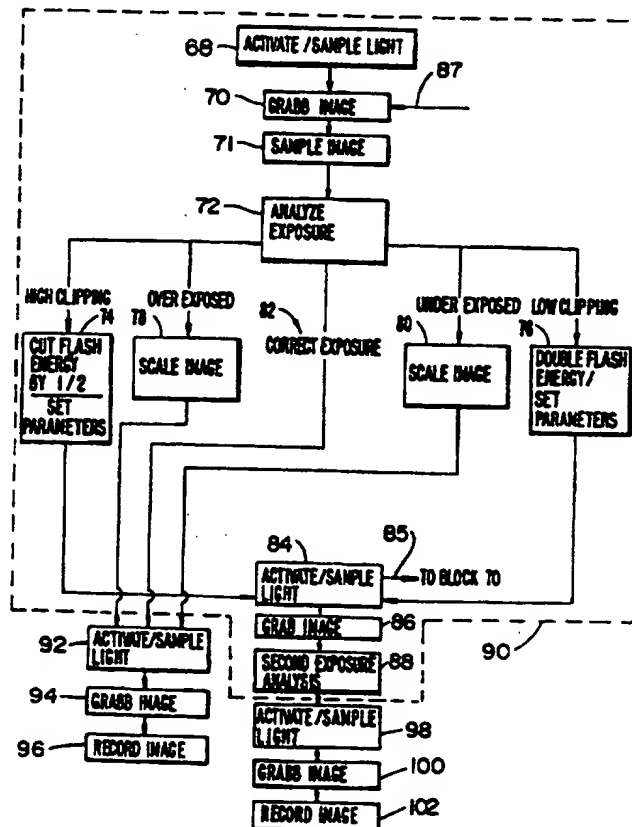
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(54) Title: INTELLIGENT CAMERA FLASH SYSTEM

## (57) Abstract

An intelligent flash system for a digital camera having components including an image optical pickup (30), an interface circuit (20), a flash unit (26) and a processor (12). Upon activation of the camera, ambient lighting conditions are evaluated and if flash energy is required, a first low energy pre-flash is radiated, the reflected light received by the optical pickup (30) having a multiplicity of pixels, and the output of the pixels converted to image intensity data by the interface circuit (20). The processor (12) samples the image intensity data, weighing the center image area (106) more heavily, and creates a histogram plot of quantity of pixels v.s. intensity, and separates the plot into a bar graph from which a determination of exposure is obtained. The histogram is then used to calculate a multiplicative scaling factor used to multiply the first flash energy to an estimate of a flash energy for correct exposure. Conditions of extreme over and under exposure result in the activation of a second flash at an adjusted energy level. The image data of the second flash is then analyzed and the exposure compared with the result of the first flash. A final determination of flash energy is then made based upon the results.



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1  
2 Specification3 INTELLIGENT CAMERA FLASH SYSTEM  
45 BACKGROUND OF THE INVENTION  
67 Field of the Invention

8 The present invention relates generally to electronic  
9 digital cameras, and more particularly to a digital camera  
10 using a pre-flash in combination with digital camera image  
11 acquisition apparatus and a processor for creating a histogram  
12 to determine an optimum flash power controlled through  
13 calculation of flash capacitor voltage.  
14

15 Brief Description of the Prior Art

16 Prior art cameras have used many different techniques to  
17 achieve optimum exposure, from hand held light meters to built  
18 in automatic exposure systems with flash. One method of  
19 controlling exposure is based on "through the lens" flash  
20 control in which the flash is terminated when sufficient light  
21 is collected by a photo receptor in the camera. Another  
22 method uses an infrared photo diode to measure the light. The  
23 advantage of using infrared is that in the infrared zone,  
24 light is more evenly reflective as a function of color in the  
25 visible spectrum. These methods are all based on an average  
26 (integration) over the entire image, and are not able to  
27 separate out important image areas for priority in setting the  
28 amount of light for exposure. For example, a combination of  
29 a close image and a distant background will result in a  
30 "washed out" foreground. Since primary subjects are often in  
31 the foreground, this is a serious problem in automatic  
32 exposure systems. These exposure control systems also require  
33 a very fast electronic switching device for a fast flash and  
34 a separate photo receptor which add complexity and cost to the  
35 system. The infrared receptor also has a problem in that the  
36 light measured is only a monochromatic estimation of the  
37 scenery. This estimation may be close in some cases, but in  
38 others, it accentuates the problem of film/CCD metamerism, a

1 condition where different wavelengths in a scene are  
2 improperly recorded.

3 In Coltman et al., U.S. Patent No. 4,998,128 the  
4 reflectivity of a subject is determined by pulsing a flash  
5 unit for predetermined short period of time. The light is  
6 detected by both visible and infrared light detectors, the  
7 outputs of which are integrated and used to select an optimum  
8 aperture and speed setting for taking the picture. In Taylor,  
9 U.S. Patent No. 4,066,884 an adjustable filter is used to vary  
10 the light intensity from an electronic flash unit, the degree  
11 of adjustment being empirically determined for a particular  
12 type of camera, in this case cameras designed for use with  
13 explosive flashbulbs which have relatively long duration of  
14 light intensity. The problem with the electronic flash unit  
15 when used with cameras having automatic exposure adjustment  
16 is that the time duration of the electronic flash is too short  
17 for the automatic exposure system to work. In Winter, U.S.  
18 Patent No. 4,549,801, an electrically operated flash camera  
19 employs an infrared flash reflected light signal stored in a  
20 single memory storage to control focus and aperture. In  
21 Ishida, U.S. Patent No. 4,256,995, an electronic flash is  
22 disclosed which is capable of emitting light for a longer  
23 duration of time so as to allow automatic exposure control  
24 camera systems to function. Kabayashi et al., U.S. Patent No.  
25 4,717,934 discloses a flash used prior to image acquisition  
26 to determine the amount of flash required for an adequate  
27 exposure. This is done by detecting and integrating light  
28 radiated directly from the flash, and integrating the  
29 reflected light from the object. The flash power is provided  
30 by a separate capacitor from the capacitor used for the main  
31 flash.

32 In Coltman, the pre-flash system functions independently  
33 from the camera image acquisition apparatus, depending on a  
34 predetermined look up table. The accuracy of this method is  
35 limited to the exactness of the correlation between the look  
36 up table and the actual setting. The mechanical adjustment  
37 device of Taylor for control of the flash intensity is  
38 dependent on the skill of the operator in knowing where to set

1 the flash cover. In Winter, the burden of adjusting for  
2 exposure is placed entirely on the camera aperture and shutter  
3 speed. No attempt is made to control the amount of flash.  
4 The device of Ishida similarly does not use control of the  
5 flash time as an aid in achieving proper exposure but simply  
6 provides a flash of long duration, allowing conventional  
7 camera automatic exposure systems to function as if the  
8 lighting were ambient. This system would consume larger  
9 amounts of flash power than what would otherwise be required  
10 for proper exposure. The device of Kabayashi requires a  
11 separate capacitor for pre-flashing, which involves extra cost  
12 and space.

13 It is apparent from the above references that an improved  
14 camera is desirable, that conserves flash power and minimizes  
15 cost and space. Also, an improved camera would provide a  
16 method for evaluating light from different parts of an image  
17 to determine optimum exposure of particularly selected areas,  
18 this being a particular problem when objects are at various  
19 distances from the camera and when they are in contrast to  
20 each other. Such a camera would be a significant improvement  
21 over the prior art.

22

23

#### SUMMARY OF THE INVENTION

24 It is therefore an object of the present invention to  
25 provide an improved digital camera having provision for  
26 determining optimum flash energy for illumination of a  
27 selected area of an image.

28 It is a further object of the present invention to  
29 provide an improved digital camera using reduced energy flash  
30 illumination to determine optimum full flash energy.

31 It is another object of the present invention to provide  
32 an improved digital camera having a flash system providing a  
33 series of lower power flashes prior to a final flash utilizing  
34 a single capacitor and providing for optimum use of flash  
35 energy.

36 It is another object of the present invention to provide  
37 an improved digital camera that uses the image acquisition

1 apparatus to determine optimum camera exposure parameters from  
2 a low energy flash prior to a final flash.

3 It is a further object of the present invention to  
4 provide a camera having a method of estimating an acquired  
5 image from data collected from low energy pre-flashes.

6 It is a still further object of the present invention to  
7 provide a camera that determines flash exposure based on  
8 center weight subsampling.

9 It is another object of the present invention to provide  
10 a method for determining the energy of sequential flashes  
11 (strokes) based on the discharge curve of the flash capacitor  
12 in a digital camera.

13 It is a further object of the present invention to  
14 provide a method of determining flash exposure based on  
15 samplings of an image luminous histogram.

16 Briefly, a preferred embodiment of the present invention  
17 includes an intelligent flash system for a digital camera  
18 having components including an image optical pickup, an  
19 interface circuit, a flash unit and a processor. Upon  
20 activation of the camera, ambient lighting conditions are  
21 evaluated and if flash energy is required, a first low energy  
22 flash is radiated, the reflected light received by the optical  
23 pickup having a multiplicity of pixels, and the output of the  
24 pixels converted to image intensity data by the interface  
25 circuit. The processor samples the image intensity data,  
26 weighing the center image area more heavily, and creates a  
27 histogram plot of quantity of pixels v.s. intensity, and  
28 separates the plot into a bar graph from which a determination  
29 of exposure is obtained. The histogram is then used to  
30 calculate a multiplicative scaling factor used to multiply the  
31 first flash energy as an estimate of a final flash energy for  
32 correct exposure. Conditions of extreme over and under  
33 exposure result in the activation of a second flash at an  
34 adjusted energy level. The image data of the second flash is  
35 then analyzed and the exposure compared with the result of the  
36 first flash. A final determination of flash energy is then  
37 made based upon the results.

1       An advantage of the present invention is the provision  
2 of a flash system for a digital camera that provides optimum  
3 flash energy.

4       A further advantage of the present invention is that it  
5 provides a flash system that uses reduced energy flashes in  
6 the determination of exposure, thus conserving total flash  
7 energy.

8       Another advantage of the present invention is the  
9 provision of a flash system that conserves flash energy and  
10 operates from a single flash capacitor.

11       A further advantage of the present invention is the use  
12 of the image acquisition optics to determine exposure, thus  
13 providing increased accuracy and a reduced parts cost.

14       It is a further advantage of the present invention to  
15 provide a flash system that determines exposure based on  
16 center weight sampling, giving greater importance in exposure  
17 determination to a more important area of the image.

18

19

#### IN THE DRAWINGS

20       Fig. 1 shows a block diagram of a digital camera  
21 according to the present invention;

22       Fig. 2 is an overall block diagram of the intelligent  
23 flash system;

24       Fig. 3 is a block diagram showing further details of the  
25 method of achieving correct exposure;

26       Fig. 4A is a sample image area illustrating the selection  
27 of a selection of a preferred object area;

28       Fig. 4B illustrates the weighted sampling of the  
29 preferred object area of Fig. 3A;

30       Fig. 5 is a simplified array of pixel intensities;

31       Fig. 6A is a simplified histogram and bar graph based on  
32 the image intensity data of Fig. 4;

33       Fig. 6B is a table of the quantities of pixels and their  
34 intensities before and after scaling;

35       Fig. 7 is a block diagram illustrating the method of  
36 exposure determination using the bar graph;

37       Fig. 8 is a more realistic histogram before and after  
38 scaling;

1        Fig. 9 is a block diagram showing the method of  
2        determining a scaling factor;

3        Fig. 10 is a block diagram illustrating the determination  
4        of flash capacitor cutoff voltage;

5        Fig. 11 is a schematic of a flash circuit; and

6        Fig. 12 is a detailed block diagram showing the analysis  
7        of the image resulting from activation of a second flash.

8

9

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

10        A typical camera system in which the method and apparatus  
11        of the present invention is employed is shown in Fig. 1,  
12        wherein a digital camera 10 is illustrated having a  
13        multiprocessor 12 activated by shutter activator 14 through  
14        line 16, and communicating through bus 18 with image interface  
15        circuit 20. The multiprocessor further communicates with  
16        memory 22 through bus 24 and interconnects with the flash unit  
17        26 through bus 28. Image optical pick-up 30 is interconnected  
18        to the image interface circuit 20 through bus 32. A power  
19        supply 34 is shown for providing electrical energy to the  
20        various circuit components through lines not shown.

21        In response to the shutter activator 14, light 36 from  
22        an image to be recorded is received by the image optical pick-  
23        up 30 and sent via bus 32 to the image interface circuit 20  
24        which communicates with the pick-up 30 and processor 12 to  
25        provide digital image intensity data corresponding to the  
26        light 36. Further details of the pick-up 30 and circuit 20  
27        are not necessary for an understanding of the present  
28        invention. Those skilled in the art of digital cameras will  
29        know how to fabricate the light to digital data apparatus.

30        According to Fig. 2, a user can select (block 38) one of  
31        two modes, including an AUTO MODE (block 40) or a MANDATORY  
32        FLASH MODE (block 42). In either of the two modes, Auto or  
33        Mandatory Flash, the processor 12 is configured to respond to  
34        the activator 14 by sampling and analyzing the ambient light  
35        (blocks 44 and 46) to determine if it is adequate. In the  
36        Auto Mode, if the ambient light is found (block 48) to be  
37        adequate, the picture is taken without a flash (block 50).  
38        If the ambient light is not adequate and a flash is needed



1 (52) the camera parameters (block 54) are set for what is  
2 defined as a "full flash mode" at which point the flash is  
3 adjusted for optimum exposure and the picture is taken (block  
4 56). This process includes a series of one or more flashes  
5 applied to determine an optimum flash energy for proper  
6 exposure. The first flash is preset at a lower energy  
7 generally considered to result in "under" exposure. If the  
8 light from the first flash is adequate for an analysis, the  
9 image is analyzed and an estimate of a proper flash energy for  
10 a correct exposure is made and the picture is taken at this  
11 flash energy. If the light from the first flash is not  
12 sufficient for an analysis, a second flash is activated at a  
13 higher energy level. The preferred embodiment provides for  
14 a maximum of two flashes prior to a flash activated to take  
15 a picture. Alternate embodiments however can use any number  
16 of flashes prior to the final flash. When sufficient light  
17 for an analysis is provided by a flash, the processor 12  
18 scales the flash energy level to determine an estimated flash  
19 energy level for correct exposure and the camera takes the  
20 picture at this energy level.

21 In the preferred embodiment, if the second flash energy  
22 level is insufficient for an analysis, i.e. resulting in  
23 either extreme under or over exposure, no further analysis is  
24 done. The picture is then taken (block 58) at a minimum flash  
25 energy level if the second flash caused extreme over exposure  
26 or at a maximum flash energy level if the result of the second  
27 flash was extreme under exposure.

28 The mandatory flash mode 42 results in the use of a flash  
29 regardless of the ambient lighting conditions, the purpose  
30 being to use the flash to fill shadows, such as on a subject  
31 person's face caused by bright sunlight. If the evaluation  
32 of ambient light (46) results in a determination (60) that a  
33 flash is needed (62), the camera parameters are set (54) as  
34 described above and the process continues according to the  
35 operations defined for blocks 56 and 58. If the ambient light  
36 is adequate, camera parameters are set 66 to reduce the  
37 ambient light input to the camera. The parameter adjustments  
38 in this case could include an increase in speed and/or a

1 reduction in the camera aperture. The correct flash power is  
2 then determined and the picture is taken as explained above  
3 according to the operations associated with blocks 56 and 58.

4 The deliberate use of a low energy first flash is for the  
5 purpose of conserving flash capacitor energy so that the flash  
6 capacitor will subsequently have enough energy for a proper  
7 final flash without recharging. This method saves energy and  
8 eliminates the need for a separate flash capacitor for the  
9 flashes prior to the final flash.

10 Referring again to Fig. 1, the light 36 from the flash  
11 is reflected from an object, received by the pick-up 30 and  
12 converted to a multiplicity of analog signals, each  
13 corresponding to one pixel in an array. These analog signals  
14 are then processed into digital image intensity data by the  
15 circuit 20 and sent to the processor 12. This process of  
16 conversion of the light to image intensity data will be termed  
17 "grabbing the image" in the following text.

18 A more detailed description of the process of analyzing  
19 the image to determine exposure and a proper final flash will  
20 now be given. This description is somewhat complicated in the  
21 fact that the process is generally applicable to the two  
22 sources of light, i.e. from ambient or other secondary light  
23 and from a flash, as indicated in blocks 44, 46 and 56. In  
24 order to avoid having to repeat a lengthy description, the  
25 following analysis will generally apply to both situations,  
26 with emphasis on the use of flash energy. The differences  
27 will be explained as the description proceeds.

28 In general, the camera 10 responds to the low energy  
29 first flash, or to a first ambient light sample by grabbing  
30 a first image (or first ambient image to distinguish the use  
31 of ambient light) and creating first image intensity (or first  
32 ambient image intensity) data. The processor 12 then  
33 constructs a first histogram and first bar graph from sampled  
34 first image intensity data, and from an analysis of this data  
35 determines a first degree of exposure, i.e. whether the object  
36 needs more or less light or whether the exposure is correct.  
37 In the above, the terminology generally also applies to an  
38 ambient/secondary light source. The terminology can be

1 distinguished from the use of flash energy by replacing the  
2 terms first histogram, first bar graph and first degree of  
3 exposure with first ambient histogram, first ambient bar graph  
4 and first ambient degree of exposure. These distinctions will  
5 now be implied in the following descriptions without  
6 repetitiously making note of them.

7       If the amount of light (first degree of exposure) is  
8 correct, a second flash or sampling is bypassed and the first  
9 flash energy level (or camera parameters for ambient light)  
10 is used to take the picture. In the case of ambient light  
11 (blocks 44 or 46), an automatic adjustment of camera  
12 parameters (speed, F-stop) would be made if the degree of  
13 exposure were not adequate. If the exposure is adequate, the  
14 picture is taken with ambient light and original parameters.  
15 If the exposure is not correct, but a meaningful histogram was  
16 created in the analysis, i.e., if the image was not greatly  
17 over or under exposed, a scaling procedure is performed on the  
18 sampled first image intensity data. This scaling procedure  
19 is performed by the processor by finding a first scaling  
20 factor to the first sampled intensity data so as to cause a  
21 predetermined percentage (.5% preferred) of the pixels to be  
22 above the saturation value of the image optical pickup  
23 (preferably a CCD). This scaling is accomplished by  
24 multiplying the sampled first image intensity data by the  
25 first scaling factor and reconstructing and re-analyzing the  
26 histogram to determine the number of pixels with intensities  
27 exceeding the saturation value. Upon finding the proper  
28 scaling factor in the case when the camera is analyzing an  
29 image from a flash, the processor uses this factor as an  
30 energy scaling factor, by which to multiply the first flash  
31 energy level to obtain an estimated correct final flash energy  
32 level. The picture is then taken with this estimated final  
33 flash energy. If the light source is ambient with no flash,  
34 the scaling factor is used with a look-up table or as an  
35 appropriate factor to determine an adjusted set of camera  
36 parameters. If the result from ambient light is a condition  
37 of extreme under exposure to such an extent that no camera  
38 speed or aperture adjustment will correct it, the camera

1 automatically shifts to the full flash mode (block 54) and the  
2 above process is activated as described in relation to the use  
3 of a first and second flash.

4 In either the case of ambient or flash light sources, the  
5 above described scaling is not performed if the degree of  
6 exposure is extremely under exposed (low clipping) or  
7 extremely over exposed (high clipping), since a meaningful  
8 histogram cannot then be prepared. If a meaningful histogram  
9 is not obtained from the first flash, due to either extreme  
10 under exposure (low clipping) or extreme over exposure (high  
11 clipping), a second flash at a second flash energy level is  
12 activated, the second flash energy level being at an adjusted  
13 fraction of the first flash. If the first degree of exposure  
14 is extremely under exposed (low clipping), the second flash  
15 energy level is adjusted to a greater energy level. If the  
16 first degree of exposure is extremely over exposed (high  
17 clipping), the second flash energy level is adjusted to a  
18 lower energy level. A second image of the object is then  
19 grabbed, and second image intensity data is created from which  
20 sampled second image intensity data is taken and a second  
21 histogram and second bar graph are created therefrom. The  
22 second histogram and second bar graph are then analyzed and  
23 a second degree of exposure determined. If high or low  
24 clipping are still occurring, the flash energy is minimized  
25 or maximized respectively and a picture is taken. If the  
26 exposure is correct, the flash is again activated at the  
27 second flash energy level to take the picture. In the case  
28 of under or over exposure, i.e., moderate under or over  
29 exposure not resulting in clipping, a second scaling factor  
30 is determined and used as a multiplicative scaling factor on  
31 the second flash energy to determine an estimated correct  
32 final flash energy. The use of the term "under exposure" and  
33 "over exposure" in the following text will generally indicate  
34 moderate "over" or "under" exposure, rather than extreme under  
35 or over exposure which will be alternatively termed low and  
36 high clipping. The above description using a maximum of two  
37 flashes prior to a final flash is the preferred embodiment,

1 however, alternate embodiments include any number of flashes  
2 prior to a final flash and are included in the invention.

3 The operation described in Fig. 2 can be more fully  
4 understood through reference to Fig. 3. The blocks 68-88  
5 included in block 90 give added detail to the operation of  
6 blocks 44-48, and 52-66 in Fig. 2. This determination of  
7 exposure in blocks 44 and 46 of Fig. 2 uses ambient light as  
8 the light sources. Block 56 uses a flash. In Fig. 3, block  
9 90 more fully describes the activity of determining the  
10 exposure. Block 68 indicates the activation of the light  
11 source, which is either a flash or a sampling of ambient  
12 light.

13 The image is then grabbed (block 70) i.e., detected by  
14 the optical pick-up 30 (Fig. 1) and processed by the interface  
15 circuit 20 to digital image intensity data. The image  
16 intensity data is then analyzed to determine a degree of  
17 exposure. This analysis involves the following operations in  
18 blocks 71 and 72 including sampling of the image intensity  
19 data in a selective manner (block 71) in order to weigh more  
20 heavily the data representing the primary object area. This  
21 area is usually considered to be near the center of the image,  
22 and such sampling is to be considered part of the preferred  
23 embodiment; however, the processor 12 could be programmed to  
24 weigh other areas more heavily and they are included in the  
25 spirit of the invention.

26 The sampled image data is then analyzed to determine the  
27 exposure (block 72), and the activity is directed accordingly.  
28 If the condition is extreme overexposure, resulting in high  
29 clipping where the large majority of pixels are at the high  
30 end of the intensity range, the process is directed to block  
31 74. If the condition is extremely under exposed, the process  
32 continues in block 76. Simple over or under exposure not  
33 resulting in clipping are directed to blocks 78 and 80  
34 respectively, and if the exposure is correct, activity  
35 continues at block 92.

36 The operations of blocks 74, 76, 78 and 80 all involve  
37 calculating either a subsequent flash energy or a subsequent  
38 set of camera parameters such as speed and aperture to sample

1 a corrected amount of light to achieve a correct exposure.  
2 The calculation is either for a subsequent flash or ambient  
3 sample to be analyzed, or a final flash energy level or set  
4 of parameters for a final sample of ambient light to take the  
5 picture. In the case of severe over exposure the operations  
6 indicated by block 74 involve setting parameters to determine  
7 the energy of a second flash when a flash is the light source,  
8 or re-setting the camera parameters such as speed and aperture  
9 if ambient light is the source. For the flash case, block 74  
10 indicates one half of the energy of the first flash, but some  
11 other fraction could be used as well. Similarly, if the  
12 condition is extremely underexposed (low clipping) where  
13 nearly all of the pixel intensities are near the low end of  
14 the intensity scale, parameters are set to direct a second  
15 flash at higher energy (block 76). Although block 76  
16 indicates doubling the energy, some other factor could be  
17 used.

18 If the condition is merely overexposed i.e. over exposed  
19 to a lesser degree and a detailed histogram can be prepared,  
20 the image data is adjusted (block 78) by a scaling factor  
21 until the histogram shows preferably .5% of the intensity data  
22 exceeding a predetermined intensity level, at which point the  
23 corresponding scaling factor is used to scale down the first  
24 flash power, or is used to determine adjusted camera  
25 parameters.

26 If the result of the analysis indicates a similar  
27 condition of under exposure to a lesser degree than low  
28 clipping so that a histogram can be created (block 80), the  
29 processing is similar to the description above for  
30 overexposure. The scaling factor for under exposure would be  
31 greater than unity, which would increase the flash energy.

32 If the first flash or ambient light sample results in a  
33 correct exposure 82, the processor proceeds directly to block  
34 92 and the flash is activated at a power level equal to the  
35 first flash energy, or in the case of ambient light, the same  
36 quantity of light is admitted/sampled again.

37 In the above cases involving over exposure 78, under  
38 exposure 80, and correct exposure 82, a second flash or

1 sampling of ambient light is not required. When the analysis  
2 shows correct exposure, the corresponding flash energy is  
3 again activated or the sampled quantity of ambient/secondary  
4 light is again sampled (block 92), the image grabbed 94 and  
5 recorded 96. In the cases of high clipping 74 and low  
6 clipping 76, either a second flash is activated 84 at an  
7 adjusted energy level, or a second ambient light sample is  
8 admitted followed by the grabbing of the image 86 and further  
9 analysis 88 and decision making in order to arrive at a  
10 correct flash energy or setting of camera parameters. In the  
11 preferred embodiment, a maximum of two flashes occur before  
12 a final flash is activated to take the picture. A larger  
13 number of flashes prior to the final flash are also included  
14 in the invention and this is indicated by arrows 85 and 87  
15 showing the operations from block 70 to 84 repeated. This  
16 repetition can be any number of times according to the  
17 programming. For example, smaller increments of flash energy  
18 adjustment in blocks 74 and 76 could be used, which could  
19 require more repetitions of analysis and adjustment to arrive  
20 at a useable flash energy from which to scale (block 78, 80)  
21 a final flash energy, or more adjustments of flash energy  
22 could be done before a final determination that the minimum  
23 or maximum flash energy should be used. Following the  
24 operation of block 88, determining optimum flash energy or  
25 camera parameters, the light source (flash or  
26 ambient/secondary) is activated 98, the image grabbed 100 and  
27 recorded 102. This is all indicated by block 88, the details  
28 of which will be fully described in the following  
29 specification in reference to the figures of the drawing.

30 The "sample image" block 71 of Fig. 3 is more fully  
31 described with reference to Figs. 4a and 4b. The image  
32 optical pick-up 30, such as a charged coupled device (CCD),  
33 contains thousands of individual receptors, i.e. pixels  
34 (picture elements). An analysis of the output of each of  
35 these elements would be a very expensive project, and for this  
36 reason the pixels are sampled (block 71). For example,  
37 suppose there were 300,000 pixels. In order to bring the  
38 analysis down to a more economical level, 1000 of the pixels

1 could be selected from the 300,000. The number of pixels and  
2 the following numbers and graphs are given by way of  
3 illustration of the method and apparatus of the present  
4 invention, and are not to be considered as limiting, since any  
5 number of pixels or any sample quantity could apply. In the  
6 example selected for illustration, a significantly greater  
7 number of pixels are sampled from the center area relative to  
8 the edges since the center of the image usually contains the  
9 primary subjects of the photography. This selective sampling  
10 gives greater weight to the lighting of the more important  
11 area of the image. For example, suppose square 104 of Fig.  
12 4 is the total area of an image. For illustration, it is  
13 partitioned into a center region 106 and an edge region 108.  
14 The camera can be set up to consider the center region 106 as  
15 being of greater importance. The area is arbitrarily selected  
16 for illustration to contain 4% of the pixels. The camera in  
17 this case would then weigh light intensity from the center 106  
18 more heavily than the edge region 108, by sampling a larger  
19 number of pixels per unit area from the center region than  
20 from the edge region. For example, Fig. 4b represents a  
21 weighted sampled image of image 104. The original region 106  
22 is now represented by region 110 occupying 25% of the total  
23 sampled image and region 108 represented by sampled region 112  
24 in Fig. 4b. In other words, a particular area of the image  
25 can be over sampled in order to weigh it as more important in  
26 determining what is a correct exposure. Although the  
27 preferred embodiment involves sampling the center region more  
28 heavily, alternate embodiments involve sampling more heavily  
29 in other areas, or in more than one selected area.

30 Block 72 of Fig. 3 includes the creation of a histogram  
31 and multiple region bar graph from the sampled image data, and  
32 evaluation of the degree of exposure as high clip, over  
33 exposed, properly exposed, under exposed or low clip. For  
34 ease of wording, the terms over exposed and under exposed will  
35 generally be used to refer to moderate over or moderate under  
36 exposure, and not to include the more severe form of under or  
37 over exposure that places pixels at one or the other extreme  
38 of the intensity scale. These more severe forms are indicated



1 by the terms low clip and high clip as referred to above, or  
2 low clipping and high clipping, or descriptively as extreme  
3 under or extreme over exposure.

4 For ease of illustration of the histogram and bar graph  
5 process, suppose the grid of 25 pixels in Fig. 5 is the  
6 sampled image intensity data. Also, for simplicity, the light  
7 intensity values are assumed to have the range of 1 to 1000.  
8 Each square 114 represents one pixel of the sampled image, and  
9 has a number assigned which is the value of light intensity  
10 of the pixel selected for illustrative purposes. In addition  
11 to sampling the image data, the processor 12 further  
12 simplifies and speeds calculations by selecting a  
13 predetermined number of regions of intensity to create a bar  
14 graph to aid in the evaluation instead of evaluating each  
15 pixel. For this illustration, suppose the number of regions  
16 of light intensity selected is five, the first region being  
17 the number of pixels with light intensities of 1-2, the second  
18 having values of 3 and 4, the third, 5 and 6, the fourth 7 and  
19 8 and the fifth, 9 and 10.

20 Fig. 6A shows a histogram, i.e., a plot of pixel quantity  
21 versus light intensity with the original quantity of each  
22 light intensity recorded as small circles. The histogram of  
23 "quantities" of pixels with a given intensity versus  
24 "intensity" is overlaid by the five region bar graph. Region  
25 1 is represented by bar 116, region 2 by bar 118, region 3 by  
26 bar 120, region 4 by bar 122 and region 5 by bar 124. Bar 124  
27 is of zero height because there are no pixels in the  
28 corresponding intensity range, which is from intensities  
29 greater than 800, up to and including 1000. The height of bar  
30 116 is the number of pixels having intensities from zero to  
31 200, including one pixel at intensity 100 and five at  
32 intensity 200, for a total of 6 pixels defining the height of  
33 the bar. The other bars are similarly derived. The modified  
34 bars 126-134 are outlined by dashed lines and are the result  
35 of the quantity of pixels having scaled intensity values, the  
36 quantities noted by the small x's. The purpose of the scaling  
37 is related to scaling in blocks 78, 80 and 88 for the purpose  
38 of arriving at a scaling factor, which is used to multiply a

1 previous flash to yield a correct final flash energy. This  
2 process will be fully described in the following discussions  
3 of the figures of the drawing. For example, the first region  
4 after intensity scaling has a quantity of pixels equal to one.  
5 The pixel initially had an intensity of 100, which is noted  
6 by the "0" identified by item no. 138. After an analysis  
7 which will be fully explained, the intensity is multiplied by  
8 a scaling factor which moves the position of the quantity  
9 notation to the intensity 106.25 indicated by the "x" and  
10 identified by item no. 136, thus shifting its position to the  
11 right on the intensity scale. The second "0" indicated by  
12 item no. 140 indicates a quantity of five pixels with  
13 intensity of 200. The scaling shifts this value above the 200  
14 limit of region 1 and into region 2 as noted by the second x  
15 identified by item no. 142. Therefore, the new region 1 has  
16 only one pixel as indicated by the dashed bar 126. A similar  
17 explanation follows for the other regions. Of particular note  
18 is region 5 which begins with no pixels, but due to the scaled  
19 values moving higher in intensity, the dashed/modified region  
20 5 has one pixel. Note also that because a multiplicative  
21 scaling factor was used, the horizontal distance (intensity  
22 difference) between the first "0" and the first "x" is much  
23 smaller than the intensity difference between the last "0" 144  
24 and last "x" 146. For ease of reference, the quantities of  
25 pixels and their intensities before and after scaling are  
26 shown in the table of Fig. 6B. The above example will be  
27 referred to in the following detailed description of the  
28 exposure analysis performed by blocks 72 and the scaling  
29 operations performed in blocks 78, 80 and 88.

30 The "analyze exposure" block 72 of Fig. 3 represents the  
31 creation and analysis of the bar graph of the actual sampled  
32 image intensity data. This analysis can now be more fully  
33 understood through reference to Fig. 7. Block 152 indicates  
34 the input of the sampled image from block 71 of Fig. 3, and  
35 blocks 154 and 156 refer to the making of the histogram and  
36 bar graph as explained above in reference to Figs. 5 and 6.  
37 According to block 158, region 1 of the bar graph is evaluated  
38 and if it contains more than a preset high value, the exposure

1 condition is termed low clipping (block 160). Similarly, in  
2 block 162, region 5 is evaluated and if it contains more than  
3 a preset value of pixels the exposure is termed high clipping  
4 (block 164). If neither high or low clipping occur, region  
5 3 is evaluated (block 166) and if the number of pixels is  
6 found to be within preset upper and lower limits, the exposure  
7 is termed to be "ok" (block 168). Otherwise, if region 3 has  
8 a high number of pixels exceeding the upper limits, region 2  
9 is evaluated (block 170). If it has a low number of pixels,  
10 the exposure is "ok" (block 172); and if not, the condition  
11 is overexposed (block 174). If the region 3 (block 166)  
12 analysis shows the number of pixels below the low limit,  
13 region 4 is evaluated for a high number of pixels (block 176).  
14 If it has a high number above a preset level, the exposure is  
15 "ok" (block 178). Otherwise, the condition is underexposed  
16 (block 180).

17 If the analysis indicates that nearly all the pixels have  
18 intensities in region 1, the exposure is termed "low clipping"  
19 or "low clip". If nearly all of the pixels have intensity in  
20 region 5, this would be high clipping (high clip). If neither  
21 low or high clipping exists, the analysis proceeds to blocks  
22 78 or 80 in Fig. 3. Referring again to the simplified example  
23 of Figs. 5 and 6, and to Fig. 8, the scaling operations  
24 performed in blocks 78 and 80 can be more fully understood.  
25 The solid line bar graph of Fig. 6A is evaluated according to  
26 block 72 explained above, and the condition would be noted as  
27 under exposed. A vertical line 148 (Fig. 6A) is marked  
28 showing the location of a value S equal to 850. S represents  
29 a point on a curve of "input light intensity" versus "output"  
30 of the image optical pickup 30 (curve not shown) where the  
31 curve becomes nonlinear, i.e. where the pickup begins to  
32 saturate, a condition indicative of excessive light input.  
33 A value "C" is also noted in Fig. 6A, marked with a line 150  
34 as the value 800. The value "C" is supposed to be the point  
35 on the distribution of pixel intensities above which lie .5%  
36 of the pixels. This point is not clear in Fig. 6A because  
37 there are only 25 total pixels and .5% is less than one. For  
38 illustrative purposes, it is placed on the value 800 which

1 includes the pixel of greatest intensity. According to a  
2 preferred embodiment of the present invention, a scaling  
3 factor  $S/C$  is defined, where  $S$  is as defined above, and  $C$  is  
4 the above defined value for a given distribution of unscaled  
5 pixels. The factor  $S/C$  is estimated by the processor 12 and  
6 used in the cases of blocks 78 and 80 to either multiply the  
7 first flash energy to obtain an estimated final flash energy  
8 for acceptable exposure, or to adjust the camera parameters  
9 if ambient light is the source. For example, in Fig. 6A, the  
10 ratio of  $S/C = 850/800 = 1.0625$ . For reference, Fig. 6B is  
11 a table giving the quantities and intensities before and after  
12 scaling for Fig. 6A. Multiplying a first flash energy by the  
13 factor  $S/C$  and activating the flash would result in a pixel  
14 intensity distribution as shown by the "x"'s in Fig. 6A, with  
15 a bar graph as indicated by the dashed lines. Note that the  
16 dashed lines are displaced horizontally from the solid lines  
17 so they can be seen, but in fact they are horizontally  
18 representative of the same intensity. Also note that the  
19 scaled plot has a pixel at the value  $S$  equal to 850. A more  
20 realistic distribution of pixels might be more instructive at  
21 this point, and such a distribution is shown in Fig. 8. The  
22 solid curve "H" represents an original distribution resulting  
23 from a first flash. The point "C" at intensity 700 is  
24 supposed to represent the intensity point above which .5% of  
25 the pixels lie. The dashed curve "H" represents the plot of  
26 the scaled intensities which should result if the pixels  
27 represented by the solid curve H are multiplied by the factor  
28  $S/C$ . In the case of Fig. 8, the value of  $S/C$  is  $S/C =$   
29  $850/700$ . Note the area above  $S = 850$  in the dashed curve.  
30 It should represent .5% of the total number of pixels. A  
31 reverse process with an  $S/C$  less than unity would result if  
32 the point C were initially above the point S, i.e.  $S/C < 1$ .  
33 The scaling processes of blocks 78 and 80 are illustrated  
34 in block form in Fig. 9. Block 182 indicates the need for the  
35 histogram of the sampled image from block 72. Block 184  
36 describes the need of the value  $S$ . Block 186 includes the  
37 operation of finding the point C on the histogram, above which

1 .5% of the pixels lie. Block 188 gives the ratio of S/C as  
2 the scaling factor.

3 Referring now to Figs. 10 and 11, the operations  
4 performed according to the "activate light source" blocks 92  
5 and 84 can be more fully understood in the case when the flash  
6 is used. Block 190 defines the inputs required. These are  
7 the desired flash energy " $E_{flash}$ ", the voltage on the flash  
8 capacitor " $V_i$ ", and the value of the flash capacitor " $C$ ". The  
9 capacitance " $C$ " of the flash capacitor is a constant, and is  
10 a predetermined, pre-programmed value. The desired flash  
11 energy " $E_{flash}$ " is determined as described in relation to blocks  
12 78 or 80, depending on whether the result of the first flash  
13 was a condition of over or under exposure, and is  $E_{flash} = S/C$   
14 ( $E_1$ ) where  $E_1$  is the previous flash.  $E_1$  is the energy of the  
15 first flash for the activate blocks 92 and 84. The  
16 determination of S/C was explained above for blocks 78 and 80.  
17 When a correct exposure condition is the result of the first  
18 flash, the value of S/C is unity.

19 In the case where high or low clipping results from first  
20 flash or a first sampled ambient light, the scaling procedure  
21 of blocks 92 and 84 is not used. In these cases the scaling  
22 factor is a predetermined setting for flash operation, either  
23 1/2 for high clipping or 2 for low clipping as indicated in  
24 blocks 74 and 76, although other values are included in the  
25 spirit of the invention. The activate flash blocks 92 and 84  
26 also define the operation of sensing the voltage  $V_i$  prior to  
27 a flash.

28 With the above discussed values of  $E_{flash}$ ,  $V_i$  and  $C$ , the  
29 processor 12 performs the calculation indicated in block 192  
30 of Fig. 10 for  $V_c$ .  $V_c$  is the value of the flash capacitor  
31 voltage at which point the desired flash energy is expended  
32 in the flash unit. Solving the equation yields

33 
$$V_c = \frac{2}{C} \sqrt{\frac{1}{2} C V_i^2 - E_{flash}}$$
  
34

35 The flash operation described above is more fully  
36 explained in reference to Fig. 11. The figure shows a  
37 capacitor 194, switch 196 and flash bulb 198 arrangement. The  
38 voltage  $V$  across the capacitor terminals 200 and 202 is

1 monitored. The value of  $V_i$  prior to a flash, as described  
2 above is measured and used in the calculation of a lesser  
3 value of voltage  $V_c$  at which point the capacitor 194 will have  
4 discharged the desired amount of energy to the flash bulb 198.  
5 The transfer of energy from the capacitor 194 to bulb 198  
6 begins when a signal on line 204 causes switch 196 to connect  
7 line 200 to line 206 to the bulb 198. When the voltage  
8 between lines 200 and 202 (across capacitor 194) is sensed to  
9 be equal to  $V_c$ , a second signal is applied on line 204 causing  
10 switch 196 to disconnect line 200 from line 206.

11 Referring to Fig. 12, there is shown a block diagram  
12 detailing the operations indicated by the second exposure  
13 analysis block 88 of Fig. 3. As discussed in reference to  
14 Fig. 3, if the exposure resulting from the first flash or  
15 first ambient light sample is either high or low clipping, a  
16 second flash or second ambient light sampling is performed of  
17 either lower or higher energy respectively for the flash, or  
18 adjusted parameters for the ambient light. This flash or  
19 sampling, described above in reference to block 84, provides  
20 an adjusted light to grab an image (block 86) which is  
21 analyzed according to block 88.

22 According to Fig. 12, the grabbed image (block 86, Fig.  
23 3) is passed as indicated by arrow 208, and is sampled (block  
24 210) and then examined according to the "analyze exposure"  
25 block 212. Blocks 210 and 212 define the same operations on  
26 the image data of the second flash or second sample as blocks  
27 71 and 72 perform on the image data from the first flash or  
28 first sample. Similarly, if the result of the analysis is a  
29 determination that the exposure is correct, the sequence of  
30 activities defined by blocks 214-220 is identical to that of  
31 blocks 92-96 of Fig. 3. This is in response to a correct  
32 exposure resulting from the first flash or first ambient light  
33 sample. The additional block 220 indicates the option of  
34 supplying a notice to the operator that the exposure is okay.  
35 This notice can be in any of a variety of forms known to those  
36 skilled in the art, such as a light bulb of any color, or LED  
37 read out, etc. In the event the second flash results in low  
38 clipping (224), the processor 12 sets the flash to a maximum

1 intensity as indicated by block 226. The flash or sample is  
2 then activated (block 228), the image is grabbed 230 and  
3 recorded 232. Similarly, if the second flash or second sample  
4 yields a high clip condition 234, the processor 12 directs the  
5 flash to a minimum (236). In the case where the light source  
6 was ambient light, the parameters are set for minimum light.  
7 The flash or sampling is then activated (228), the image  
8 grabbed (block 230) and recorded (232).

9 If the result of the second flash or second ambient  
10 sample is a condition of under exposure (238) meaning a  
11 condition not severe enough to be low clipping, and if the  
12 result of the first flash (240) or first sampling is under  
13 exposure 242, the second flash or sampling is scaled with a  
14 scaling factor S/C as indicated by block 244. The process of  
15 determining the scale factor S/C is the same as that described  
16 above in reference to block 80 of Fig. 3. The flash or  
17 sampling is then activated (228). In the case of a flash, the  
18 energy is set to a level equal to  $E_2(S/C)$  where  $E_2$  is the  
19 second flash energy and S/C is the scaling factor. In the  
20 case of ambient light, the parameters of the last sampling are  
21 scaled to adjusted parameters using the factor S/C and an  
22 optional look-up table. The image is then grabbed 230 and  
23 recorded 232. Similarly, if the first result is "over  
24 exposure" (246), the preferred embodiment simply scales the  
25 second flash energy level or the camera parameters for ambient  
26 light (block 248) by determining the scale factor S/C. The  
27 determination of the scale factor S/C is again done in the  
28 same way as that described in relation to block 80 of Fig. 3.

29 In the case where the analysis of the sampled image of  
30 the second flash results in a condition of over exposure  
31 (250), and the result of the first flash (252) is under  
32 exposure (254), the second flash energy is scaled by the value  
33 S/C (block 248) to obtain the final flash energy. Also, if  
34 the first flash is over exposed (256), the second flash energy  
35 is again scaled (block 258) by the value S/C for final flash  
36 energy. Similarly for an ambient light source, the camera  
37 parameters are scaled from the parameters used in the second  
38 light sampling. The scaling operations in blocks 244, 248 and

1 258 are all similar to the scaling operations of blocks 78 and  
2 80 as described in reference to Fig. 3. The only difference  
3 is that the scaling blocks of Fig. 12 scale the second flash  
4 energy or second camera parameters rather than the first.  
5 Also, it should be pointed out that scaling the second flash  
6 energy/parameter is done for simplicity in the cases where the  
7 second exposure image is under exposed and the first image is  
8 over exposed (ref. 238 and 246), and the case when the second  
9 image is over exposed and the first is under exposed (refs.  
10 250 and 254). Alternate embodiments of the invention include  
11 exposure methods of scaling in block 248 when the first and  
12 second exposure bracket the correct exposure. For example,  
13 in the case where the first exposure results in under exposure  
14 and the second results in over exposure, a weighted average  
15 could be used. For the flash case, an example could be to  
16 assume a final flash energy  $E_w = A(E_2 - E_1) + E_1$  where A is a  
17 preset fraction between zero and one, the selected value  
18 depending on the estimated accuracy of the second flash. For  
19 example, it would normally be assumed that the second flash  
20 energy is closer to correct than the first and a choice of A  
21 = .7 might be selected. Other weighted averages are also  
22 included in the spirit of the present invention.

23 The "Notice" blocks 260-268 define an optional visual or  
24 recorded message to the operator of the particular exposure  
25 condition existing when a picture is taken.

26 Although a preferred embodiment of the present invention  
27 has been described above, it will be appreciated that certain  
28 alterations or modifications thereon will be apparent to those  
29 skilled in the art. It is therefore that the appended claims  
30 be interpreted as covering all such alterations and  
31 modifications that fall within the true spirit and scope of  
32 the invention.

33



1 What is claimed is:

CLAIMS

1 1. A flash method for a digital camera, said method  
2 comprising:

3 a) activating a flash with a flash energy;

4 b) grabbing an image to create image intensity data;

5 c) analyzing corresponding image intensity data of an  
6 image derived from said flash to determine a flash degree of  
7 exposure;

8 d) calculating a subsequent flash energy level to achieve  
9 a corrected degree of exposure;

10 e) repeating steps (a) through (d) until an acceptable  
11 final flash energy level for achieving a correct exposure is  
12 determined; and

13 f) activating a flash at the determined acceptable final  
14 flash energy.

1 2. A method as in claim 1 further comprising a step prior  
2 to step (a) consisting of determining by analysis of ambient  
3 light or user election whether a flash is needed.

1 3. A method as recited in claim 1 wherein said calculating  
2 includes multiplying the energy level of said flash by a pre-  
3 set constant factor if said flash degree of exposure is  
4 severely under exposed or severely over exposed.

1 4. A method as recited in claim 1 wherein said calculating  
2 further includes

- 3       a) setting said subsequent flash energy level at the  
4       maximum flash energy level for a final flash energy level if  
5       two or more consecutive flash degrees of exposure are severely  
6       under exposed; and
- 7       b) setting said subsequent flash energy level at a  
8       minimum flash energy level for a final flash energy level if  
9       two or more consecutive flash degrees of exposure are severely  
10      over exposed.

- 1      5.    A method as recited in claim 1 wherein said activating  
2      a flash with a flash energy includes
- 3           a) detecting an initial voltage of a flash capacitor;  
4           b) calculating a cutoff voltage of said flash capacitor  
5      at which voltage a quantity of energy equal to said flash  
6      energy is transferred to power said flash; and
- 7           c) transferring a quantity of energy equal to said flash  
8      energy to said flash.

- 1      6.    A method as recited in claim 1 wherein said analyzing  
2      includes
- 3           a) sampling a first quantity of data from a first area  
4      of said image; and
- 5           b) sampling a second quantity of data from a second area  
6      of said image.

- 1      -7.   A method as recited in claim 1 wherein said analyzing  
2      further includes

- 3           a) creating a histogram of quantity of said image  
4 intensity data versus intensity;  
5           b) preparing a bar graph with a multiplicity of regions  
6 from said histogram; and  
7           c) evaluating the quantity of data in each said region  
8 of said bar graph.

1   8.   A method as recited in claim 7 wherein said calculating  
2 includes scaling said image intensity data to determine a  
3 scaling factor to multiply times said flash energy to  
4 calculate a final acceptable flash energy if said degree of  
5 exposure is under exposed or over exposed.

1   9.   A method as recited in claim 8 wherein said scaling said  
2 image intensity data includes

3           a) evaluating said histogram to determine a first  
4 intensity level above which a predetermined percentage of said  
5 intensity data lie; and

6           b) dividing a predetermined intensity level selected as  
7 a level at which said grabbing to create image intensity data  
8 becomes non-linear, by said first intensity level to create  
9 said scaling factor.

1   10.  A method as recited in claim 1, wherein said calculating  
2 includes calculating a weighted average of a first energy  
3 level of a flash which resulted in under exposure, and a  
4 second energy level which resulted in over exposure to obtain  
5 an estimated final flash energy level.

1 11. A method as recited in claim 2, wherein said determining  
2 by analysis includes

3 a) sampling a quantity of ambient light with said camera  
4 having a first set of camera parameters;

5 b) grabbing an image to create image intensity data;

6 c) analyzing corresponding image intensity data of an  
7 image derived from said ambient light to determine an ambient  
8 degree of exposure;

9 d) calculating subsequent camera parameters to sample a  
10 quantity of ambient light to achieve a corrected degree of  
11 exposure; and

12 e) repeating steps (a) through (d) until a said set of  
13 camera parameters are determined resulting in an acceptable  
14 quantity of ambient light for achieving a correct exposure,  
15 or until it is determined that a flash is needed.

1 12. A method as recited in claim 11 further comprising:

2 sampling a quantity of ambient light equal to said  
3 acceptable quantity of ambient light.

1 13. A method as recited in claim 3 wherein said calculating  
2 further includes

3 a) setting said subsequent flash energy level at the  
4 maximum flash energy level for a final flash energy level if  
5 two or more consecutive flash degrees of exposure are severely  
6 under exposed; and

7 b) setting said subsequent flash energy level at a  
8 minimum flash energy level for a final flash energy level if

9 two or more consecutive flash degrees of exposure are severely  
10 over exposed.

1 14. A flash method for a digital camera, said method  
2 comprising:

3 a) activating a flash with a first flash energy;

4 b) grabbing a first image to create first image intensity  
5 data;

6 c) analyzing corresponding first image intensity data of  
7 said first image derived from said first flash to determine  
8 a first degree of exposure;

9 d) scaling said first flash energy if said first degree  
10 of exposure is under or over exposed to determine a final  
11 flash energy level; and

12 e) activating said flash at said final flash energy  
13 level.

1 15. A flash method as recited in claim 14 further comprising:

2 a) multiplying said first energy level by a pre-  
3 determined factor if said first degree of exposure is severely  
4 under exposed or severely over exposed to determine a second  
5 flash energy level;

6 b) activating said flash with said second flash energy  
7 level;

8 c) grabbing a second image to create second image  
9 - intensity data;

- 10           d) analyzing corresponding second image intensity data  
11 of said second image derived from said second flash to  
12 determine a second degree of exposure;  
13           e) scaling said second flash energy level if said second  
14 degree of exposure is under exposed or over exposed to  
15 determine a final flash energy; and  
16           f) activating said flash with said final flash energy.

1   16. A flash method as recited in claim 15, further  
2 comprising:

3           a) setting a final flash energy equal to a maximum flash  
4 energy if said second degree of exposure is severely under  
5 exposed;

6           b) setting a final flash energy equal to a minimum flash  
7 energy if said second degree of exposure is severely over  
8 exposed; and

9           c) activating said flash with said final flash energy.

1   17. A flash apparatus for a digital camera, said apparatus  
2 comprising:

3           a) means for activating a flash with a flash energy;

4           b) means for grabbing an image to create image intensity  
5 data;

6           c) means for analyzing corresponding image intensity data  
7 of an image derived from said flash to determine a flash  
8 degree of exposure;

9           d) means for calculating a subsequent flash energy level  
10 to achieve a corrected degree of exposure;

11 e) means for repeating steps (a) through (d) until an  
12 acceptable final flash energy level for achieving a correct  
13 exposure is determined; and

14 f) means for activating a flash at the determined  
15 acceptable final flash energy.

1 18. An apparatus as in claim 17 further comprising means for  
2 determining by analysis of ambient light or user election  
3 whether a flash is needed.

1 19. An apparatus as recited in claim 17 wherein said means  
2 for calculating includes means for scaling said image  
3 intensity data to determine a scaling factor to multiply times  
4 said flash energy to calculate a final acceptable flash energy  
5 if said degree of exposure is under exposed or over exposed.

1 20. An apparatus as recited in claim 17 wherein said means  
2 for activating a flash with a flash energy includes

3 a) means for detecting an initial voltage of a flash  
4 capacitor;

5 b) means for calculating a cutoff voltage of said flash  
6 capacitor at which voltage a quantity of energy equal to said  
7 flash energy is transferred to power said flash; and

8 c) means for transferring a quantity of energy equal to  
9 send flash energy to said flash.

1 21. An apparatus as recited in claim 17 wherein said means  
2 for analyzing includes



3       a) means for sampling a first quantity of data from a  
4 first area of said image; and

5       b) means for sampling a second quantity of data from a  
6 second area of said image.

1   22. An apparatus as recited in claim 17 wherein said means  
2 for analyzing further includes

3       a) means for creating a histogram of quantity of said  
4 image intensity data versus intensity;

5       b) means for preparing a bar graph with a multiplicity  
6 of regions from said histogram; and

7       c) means for evaluating the quantity of data in each said  
8 region of said bar graph.

1   23. An apparatus as recited in claim 19 wherein said means  
2 for scaling said image intensity data includes

3       a) means for evaluating said histogram to determine a  
4 first intensity level above which a predetermined percentage  
5 of said intensity data lie; and

6       b) means for dividing a predetermined intensity level  
7 selected as a level at which said grabbing to create image  
8 intensity data becomes non-linear, by said first intensity  
9 level to create said scaling factor.

1   24. An apparatus method as recited in claim 17, wherein said  
2 means for calculating includes means for calculating a  
3 weighted average of a first energy level of a flash which

4 resulted in under exposure, and a second energy level to  
5 obtain an estimated final flash energy level.

1 25. A flash apparatus for a digital camera, said apparatus  
2 comprising:

3 a) means for activating a flash with a first flash  
4 energy;

5 b) means for grabbing a first image to create first image  
6 intensity data;

7 c) means for analyzing corresponding first image  
8 intensity data of said first image derived from said first  
9 flash to determine a first degree of exposure;

10 d) means for scaling said first flash energy if said  
11 first degree of exposure is under or over exposed to determine  
12 a final flash energy; and

13 e) means for activating said flash at said final flash  
14 energy level.

1 26. A flash apparatus as recited in claim 25 further  
2 comprising:

3 a) means for multiplying said first energy level by a  
4 pre-determined factor if said first degree of exposure is  
5 severely under exposed or severely over exposed to determine  
6 a second flash energy level;

7 b) means for activating said flash with said second flash  
8 energy level;

9 c) means for grabbing a second image to create second  
10 image intensity data;

11       d) means for analyzing corresponding second image  
12 intensity data of said second image derived from said second  
13 flash to determine a second degree of exposure;

14       e) means for scaling said second flash energy level if  
15 said second degree of exposure is under exposed or over  
16 exposed to determine a final flash energy; and

17       f) means for activating said flash with said final flash  
18 energy.

1   27. A flash apparatus as recited in claim 26, further  
2 comprising:

3       a) means for setting a final flash energy equal to a  
4 maximum flash energy if said second degree of exposure is  
5 severely under exposed;

6       b) means for setting a final flash energy equal to a  
7 minimum flash energy if said second degree of exposure is  
8 severely over exposed; and

9       c) means for activating said flash with said final flash  
10 energy.

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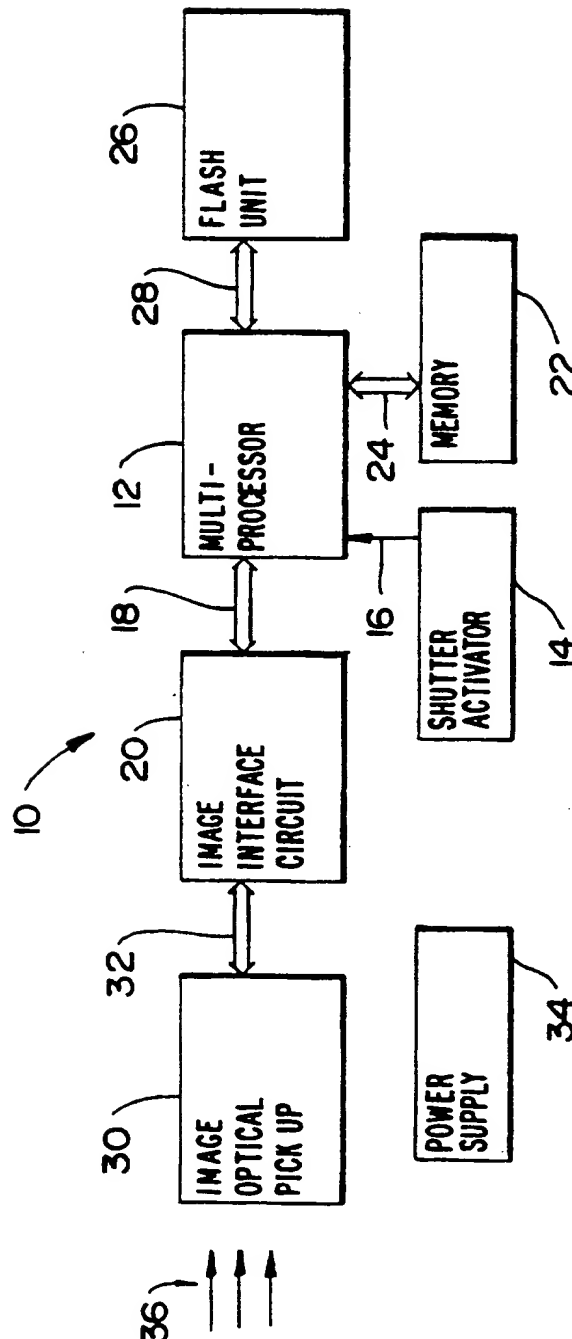


Fig - 1

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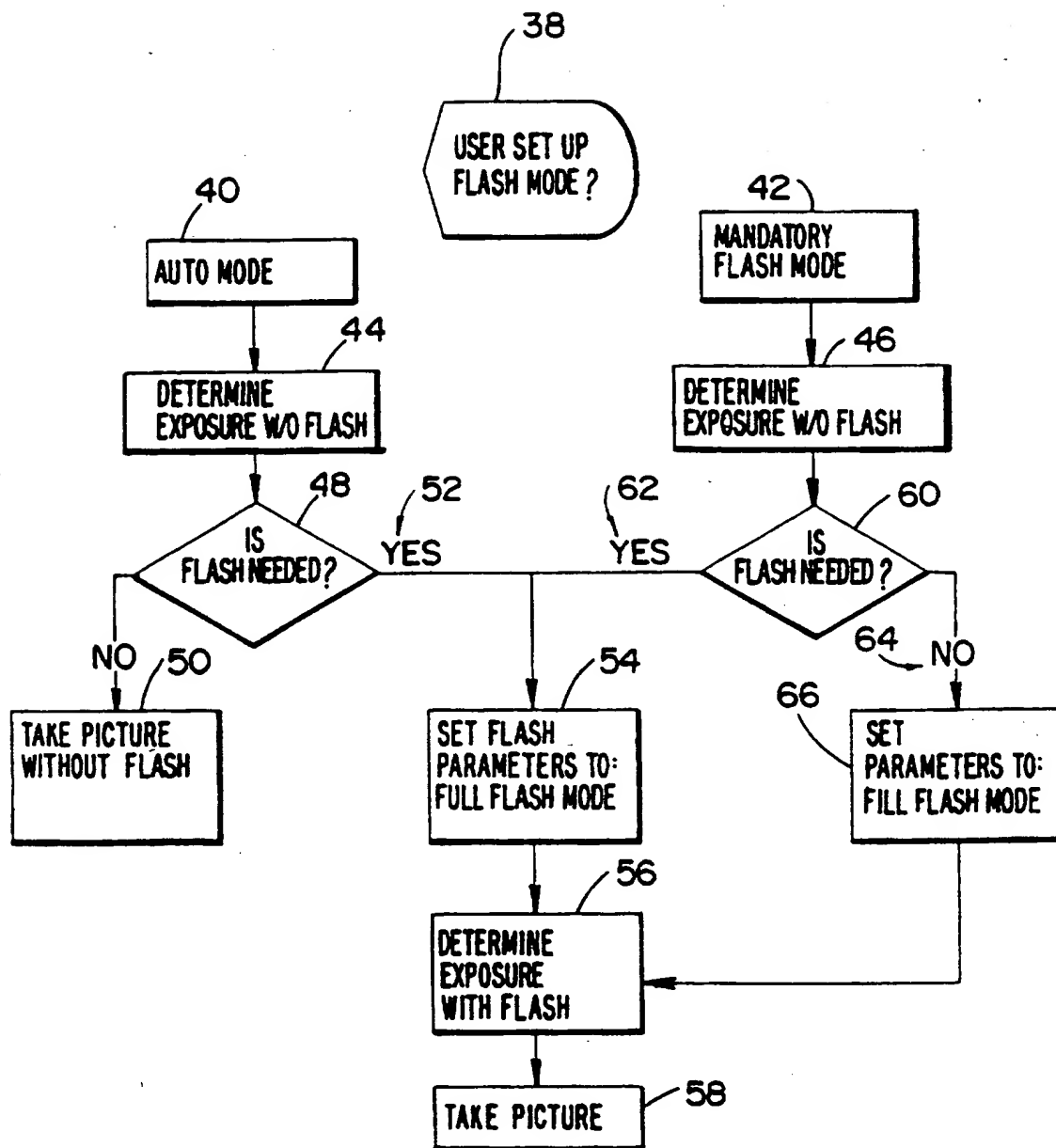


Fig - 2

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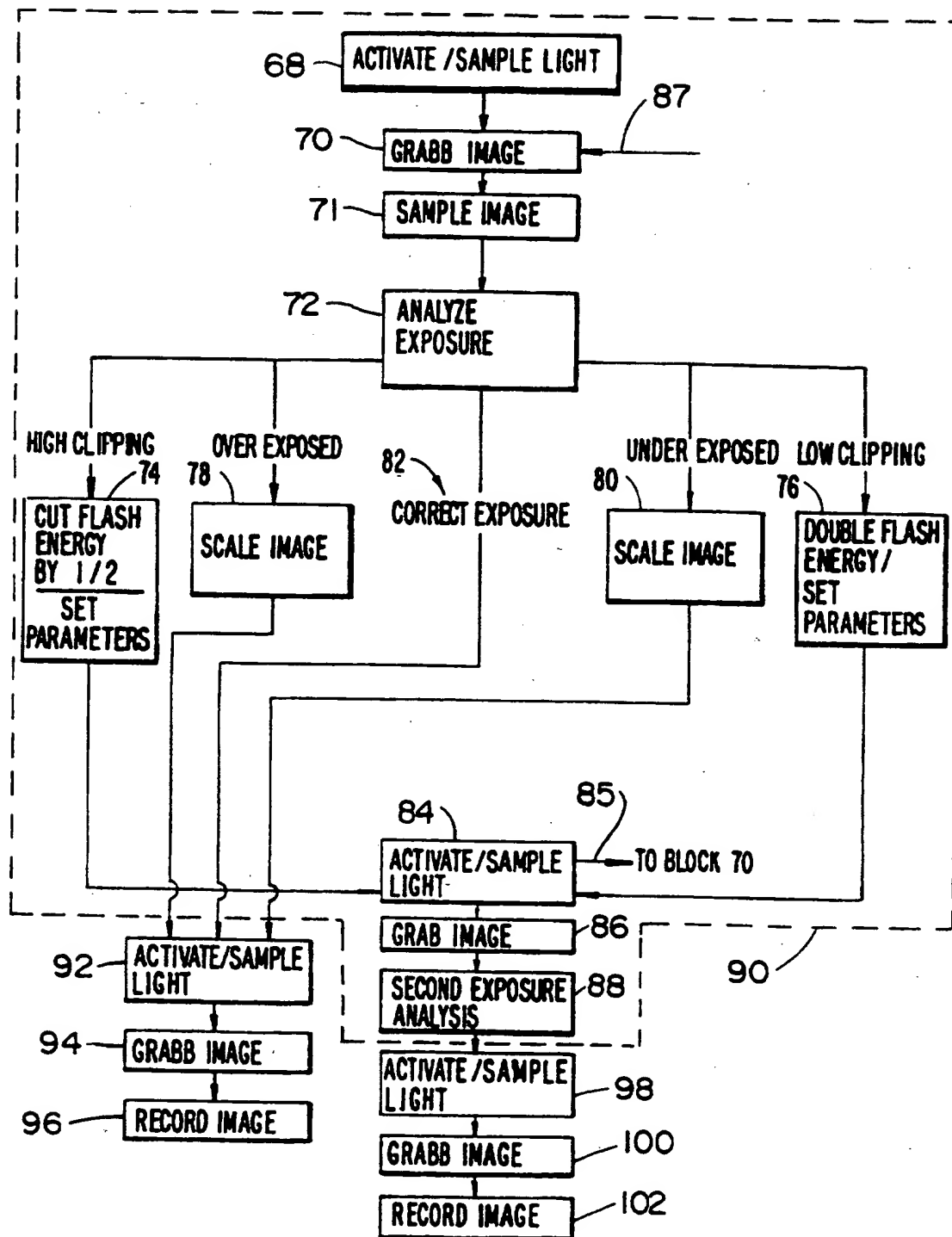
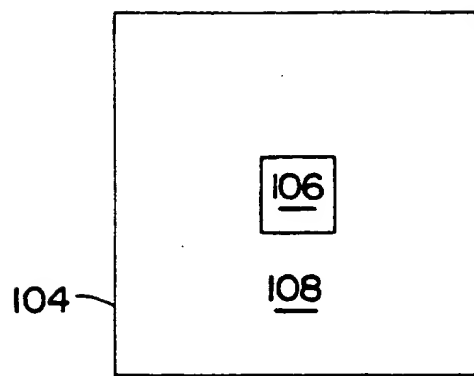
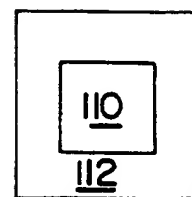


Fig. 3

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Fig - 4AFig - 4B

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500	400	300	200	200
600	300	400	500	300
400	300	600	700	400
200	500	800	700	300
100	200	300	400	200

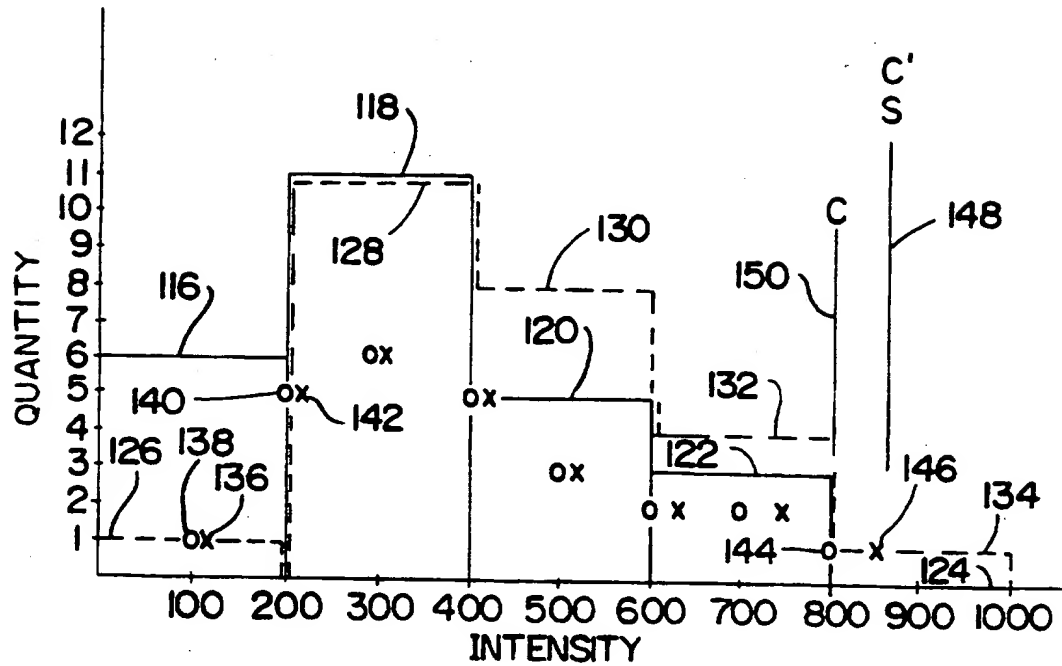
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Fig - 5

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Fig - 6A



QTY	ORIGINAL INTENSITY	SCALED INTENSITY
1	100	106.25
5	200	212.50
6	300	318.75
5	400	425.00
3	500	531.25
2	600	637.50
2	700	743.75
1	800	850.00
0	900	
0	1000	

Fig - 6B

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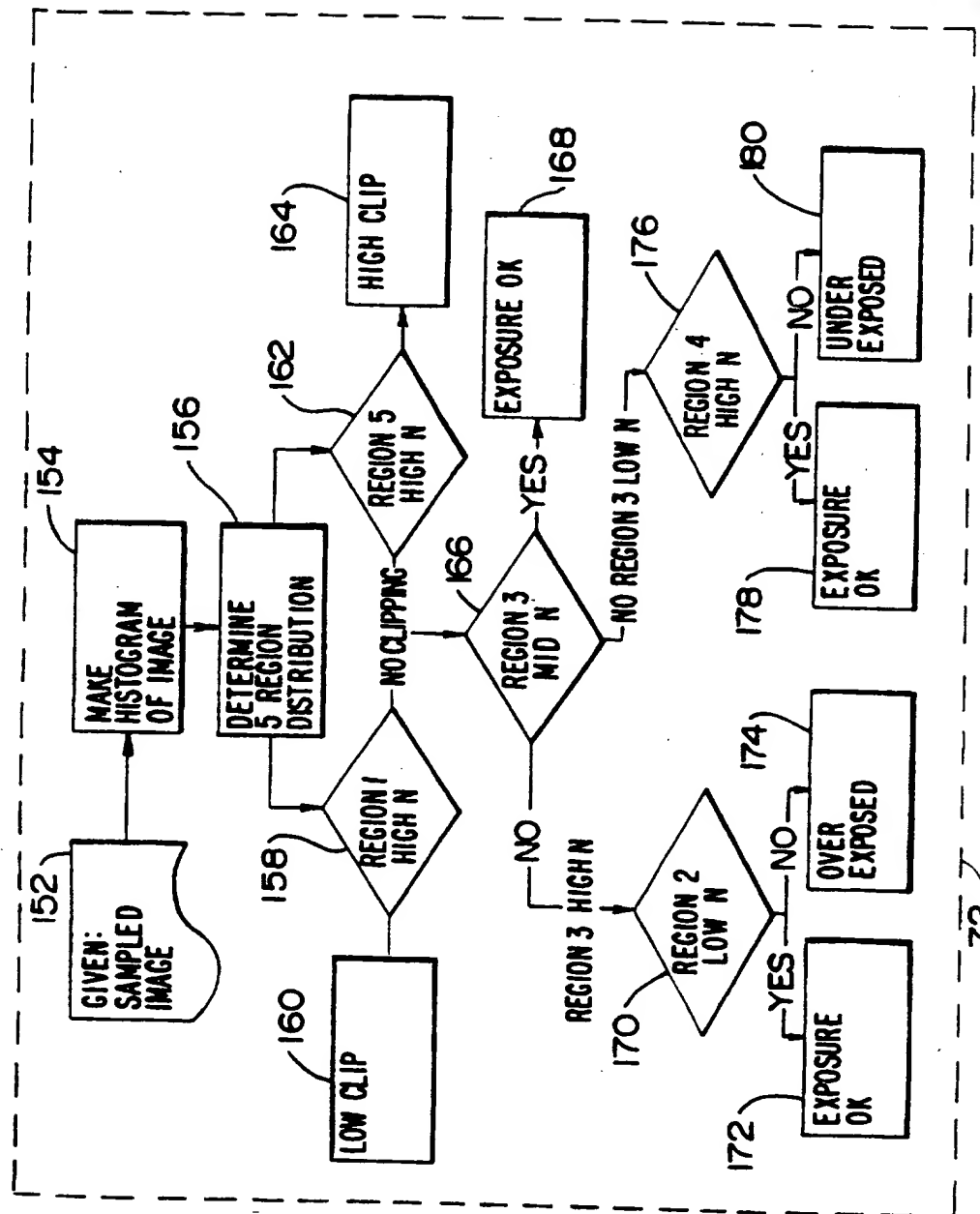


FIG. 7

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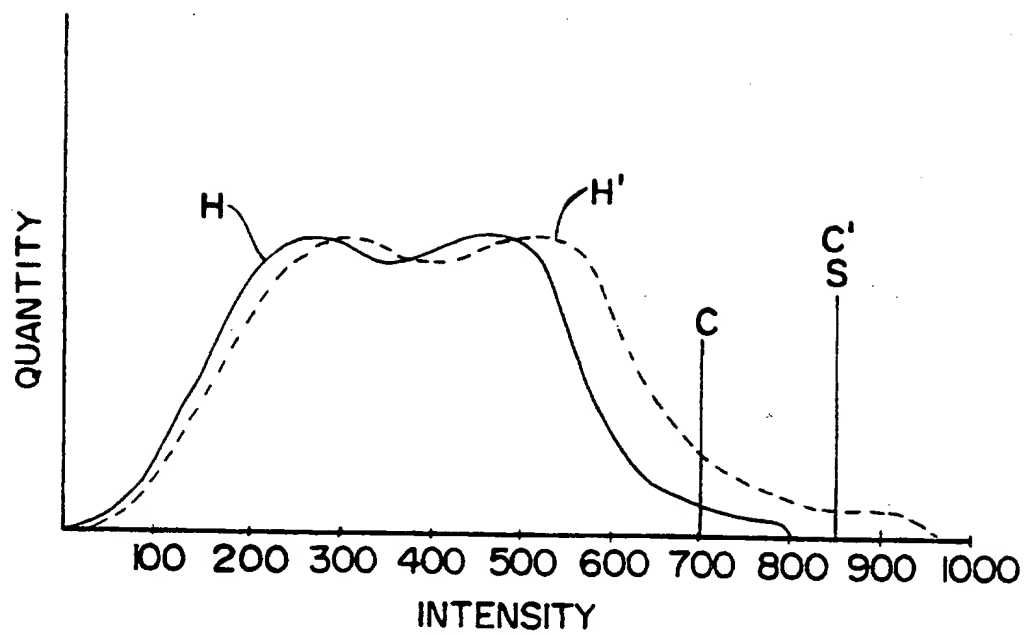
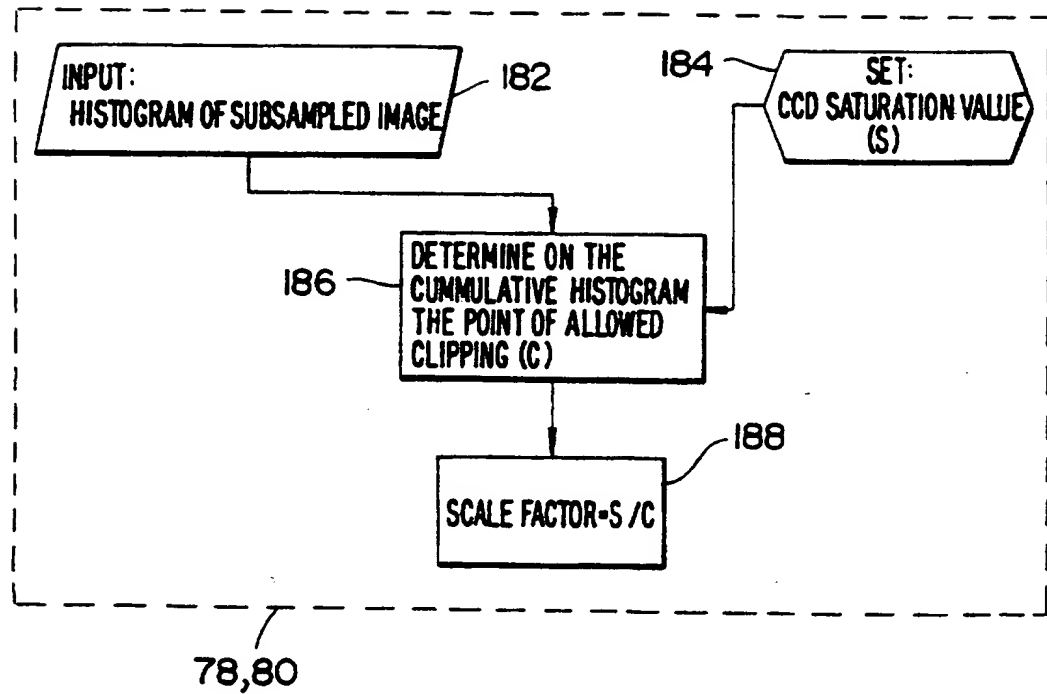


Fig - 8

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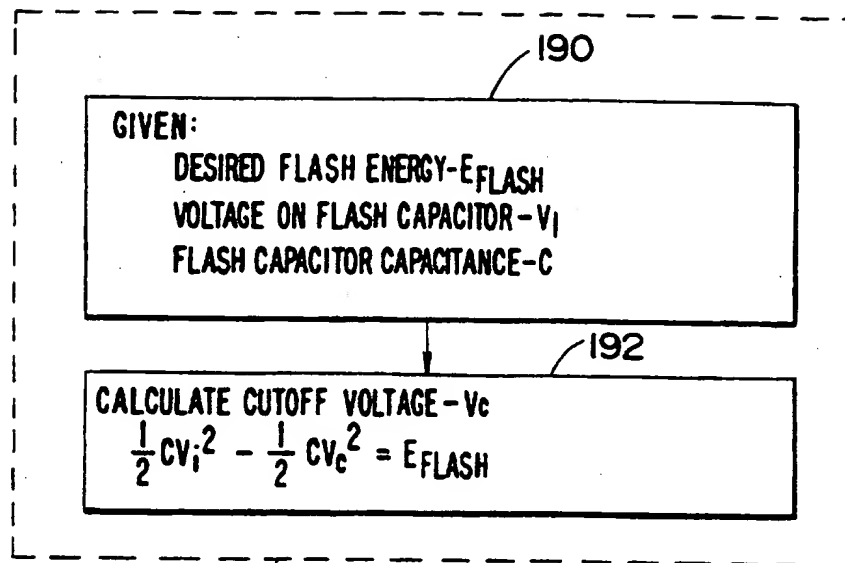
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Fig - 10

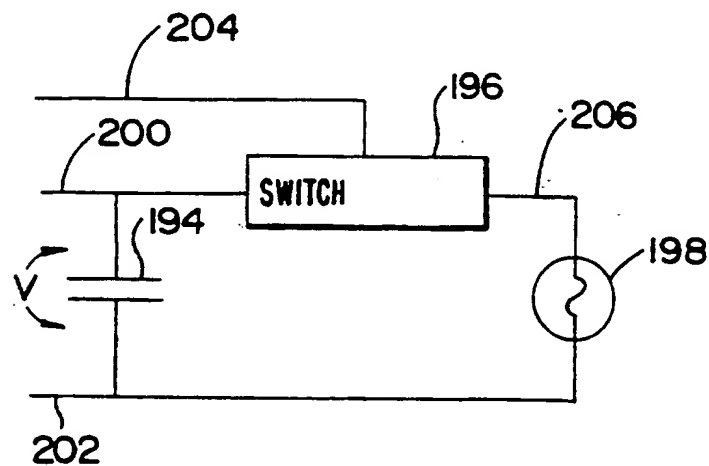
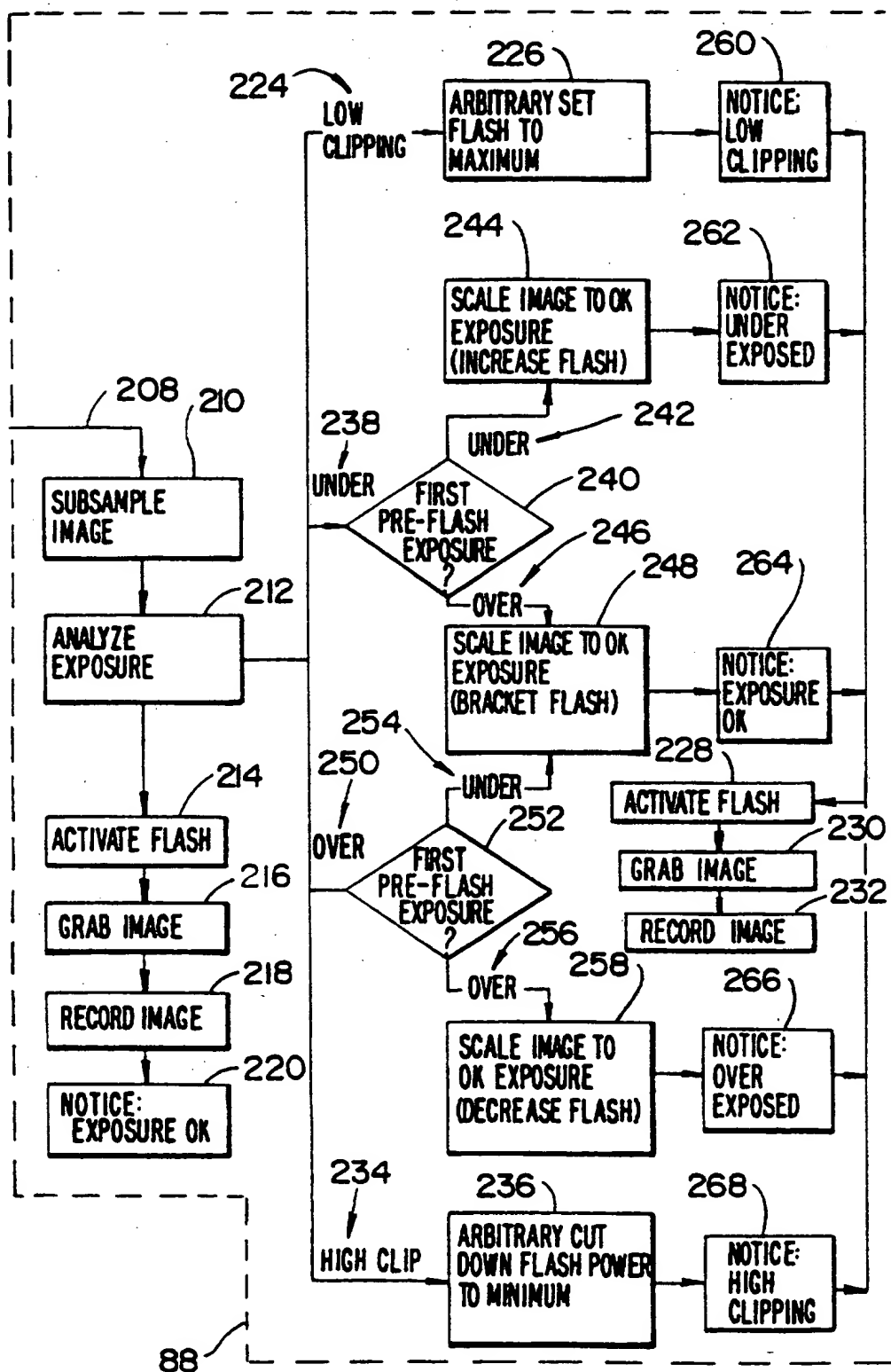


Fig - 11

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## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/04998

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04N 9/73, 5/238, 5/222; G03B 7/00

US CL : 348/222, 224, 362, 363, 364, 366, 370, 371

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/222, 224, 362, 363, 364, 366, 370, 371

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,535,758 A (LONGACRE, Jr.) 20 August 1985, col. 3 line 61 - col. 4, line 35.	1, 17, 14, 25
Y	US 5,001,552 A (OKINO) 19 March 1991, col. 7 line 49 to col. 9 line 19.	2, 11, 12, 18
Y	US 5,019,911 A (OKINO et al) 28 May 1991, col. 7 line 61 to col. 8 line 38.	5, 20
A	US 5,065,232 A (KONDO) 12 November 1991, col. 4, lines 13-61.	1, 17, 14, 25
Y	US 5,194,960 A (OTA) 16 March 1993, col. 13 line 15 to col. 16 line 9, col. 19 line 10 to col. 21 line 22, col. 22 line 54 to col. 24 line 24.	7-10, 22, 23

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	* T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
* A document defining the general state of the art which is not considered to be part of particular relevance	* X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
* E earlier document published on or after the international filing date	* Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
* L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	* &	document member of the same patent family
* O document referring to an oral disclosure, use, exhibition or other means		
* P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

12 MAY 1997

Date of mailing of the international search report

09 JUN 1997

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/04998

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,438,367 A (YAMAMOTO et al) 01 August 1995, col. 10 line 26 to col. 12 line 40.	1, 3-4, 6, 13-14, 17, 19, 21, 25